

# Latest Benchmark Results

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## Services we provide

- Guide to Software: "**Decision Tree**"
- <http://plato.asu.edu/guide.html>
- Software Archive
- Software Evaluation: "**Benchmarks**"
- Archive of Testproblems
- Web-based Solvers (**1/3 of NEOS**)

We maintain the following NEOS solvers in 9 categories

Combinatorial Optimization \* CONCORDE [TSP Input]

Global Optimization \* ICOS [AMPL Input]

\* scip [AMPL Input][LP Input][MPS Input][OSIL Input][ZIMPL Input]

Linear Programming

\* bmpd [AMPL Input][LP Input][MPS Input][QPS Input]

\* SoPlex80bit [LP Input][MPS Input]

Mixed Integer Linear Programming

\* feaspump [AMPL Input][LP Input][MPS Input]

\* proxy [LP Input][MPS Input]

\* qsopt\_ex [AMPL Input][LP Input][MPS Input]

\* scip [AMPL Input][LP Input][MPS Input][ZIMPL Input][OSIL Input]

Nondifferentiable Optimization \* condor [AMPL Input]

Semi-infinite Optimization \* nsips [AMPL Input]

## Mixed Integer Nonlinearly Constrained Optimization

\* scip [AMPL Input][LP Input][MPS Input][OSIL Input][ZIMPL Input]

## Semidefinite (and SOCP) Programming (also discrete)

\* csdp [MATLAB\_BINARY Input][SPARSE\_SDPA Input]

\* mosek [MATLAB\_BINARY Input][SPARSE\_SDPA Input]

\* penbmi [MATLAB Input][MATLAB\_BINARY Input][YALMIP Input]

\* pensdp [MATLAB\_BINARY Input][SPARSE\_SDPA Input]

\* scipsdp [SPARSE\_SDPA Input]

\* sdpa [MATLAB\_BINARY Input][SPARSE\_SDPA Input]

\* sdplr [MATLAB\_BINARY Input][SDPLR Input][SPARSE\_SDPA Input]

\* sdpt3 [MATLAB\_BINARY Input][SPARSE\_SDPA Input]

\* sedumi [MATLAB\_BINARY Input][SPARSE\_SDPA Input]

## Stochastic Linear Programming

\* bnbs [SMPS Input]

\* DDSIP [LP Input][MPS Input]

\* SD [SMPS Input]

=====  
Usage of our NEOS solvers within last twelve months  
=====

Concorde	30,000
SCIP	14,000
BPMPD	3,500
PENBMI	2,300
QSOPT_ex	1,400
SCIP_SDP	1,100
CSDP, SDPA, SD, SDPLR	1,000
others below	1,000

# Overview of Talk

- **Current and Selected Benchmarks**
  - **Benchmarks of Continuous Optimization Software**
    - \* **Simplex/Barrier LP/QP/SOCP, SDP, NLP, MPEC**
  - **Benchmarks of Discrete Optimization Software**
    - \* **MILP, MIQP, MIQCP, MISOCP, MINLP**
- **Observations and Conclusions**

## **COMBINATORIAL OPTIMIZATION**

Concorde-TSP with different LP solvers (12-20-2017)

## **LINEAR PROGRAMMING**

- \* Benchmark of Simplex LP solvers (10-17-2018)
- \* Benchmark of commercial LP solvers (10-17-2018)
- Parallel Barrier Solvers on Large LP/QP problems (10-17-2018)
- Large Network-LP Benchmark (commercial vs free) (10-17-2018)

## **SEMIDEFINITE/SQL PROGRAMMING**

- SQL problems from the 7th DIMACS Challenge (8-8-2002)
- Several SDP codes on sparse and other SDP problems (10-25-2018)
- Infeasible SDP Benchmark (5-9-2018)
- \* Large SOCP Benchmark (10-17-2018)
- \* MISOCP Benchmark (10-17-2018)

## **PROBLEMS WITH EQUILIBRIUM CONSTRAINTS**

MPEC Benchmark (4-17-2018)

## **MIXED INTEGER LINEAR PROGRAMMING**

- \* MILP Benchmark - MIPLIB2010 (10-21-2018)
- \* MILP Benchmark - MIPLIB2017 (11-1-2018)
- \* MILP cases that are slightly pathological (10-30-2018)
- Feasibility Benchmark (11-1-2018) (MIPLIB2017)
- Infeasibility Detection for MILP Problems (11-1-2018) (MIPLIB2017)

## **NONLINEAR PROGRAMMING**

- \* AMPL-NLP Benchmark (10-30-2018)

## **MIXED INTEGER QPs and QCPS**

- Non-commercial convex QP Benchmark (8-17-2018)
- \* Binary QPLIB Benchmark (10-30-2018)
- \* QPLIB-QCQP Benchmark (7-27-2018)
- \* Convex Discrete QPLIB Benchmark (10-30-2018)

## **MIXED INTEGER NONLINEAR PROGRAMMING**

- MINLP Benchmark (6-14-2018)



## Important features of all our benchmarks

- NO PERFORMANCE PROFILES! (unreliable, TOMS 43)
- Statistics of problems (dimensions etc)
- Links to codes, problems and logfiles given
- Same selection for commercial/free codes
- many benchmark talks on personal webpage to  
TRACK PERFORMANCE OVER TIME

## Reasons for updates

- New versions of commercial software
  - GUROBI-8.1, XPRESS-8.5.1, SAS-OR-14.6 (soon)
  - KNITRO-11.1, MOSEK-8.1
  - MATLAB-2018b (linprog, intlinprog, fmincon)
  - GAMS-25.1 (for MINLP)
- New versions of free software
  - MIPCL, SCIP, IPOPT, GALAHAD-CQP

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17 Oct 2018 =====  
 Benchmark of Simplex LP solvers  
 =====  
 H. Mittelmann (mittelmann@asu.edu)

This benchmark was run on a Linux-PC (i7-4790K, 4.0GHz, 32GB).

CPLEX-12.8.0 CPLEX  
 GUROBI-8.1.0 www.gurobi.com/  
 MOSEK-8.1.0.63 www.mosek.com  
 XPRESS-8.5.1 XPRESS (1/8 threads)  
 CLP-1.16.11 projects.coin-or.org/Clp (with openblas)  
 Google-GLOP LP with Glop  
 SOPLEX-4.0.0 soplex.zib.de/  
 LP\_SOLVE-5.5.2 lpsolve.sourceforge.net/  
 GLPK-4.64 www.gnu.org/software/glpk/glpk.html  
 MATLAB-R2018a mathworks.com (dual-simplex)  
 SAS-OR-14.3 SAS optimization

Unscaled and scaled shifted (by 10 sec) geometric mean of runtimes

	49.3	22.8	142	26.2	50.0	292	461	5068	1180	298	147
	2.16	1	6.21	1.15	2.19	12.8	20.2	222	52	13.1	6.43
solved	40	40	39	40	40	36	36	23	31	32	38
=====											
40 probs	CPXS	GRBS	MSKS	XPRS	CLP	GLOP	SOPLX	LPSLV	GLPK	MATL	SAS
=====											

```

17 Oct 2018  =====
              Benchmark of commercial LP solvers
              =====
              H. Mittelmann (mittelmann@asu.edu)

```

This benchmark was run on a Linux-PC (i7-4790K, 4GHz, 32GB).

The barrier(B) and deterministic automatic/concurrent(C) methods were tested of:

```

CPLEX-12.8.0    CPLEX
GUROBI-8.1.0    www.gurobi.com/
MOSEK-8.1.0.63  www.mosek.com
XPRESS-8.5.1    XPRESS
MATLAB-R2018a   mathworks.com (interior-point, NO CROSSOVER!)
SAS-OR-14.3     SAS

```

Unscaled and scaled shifted (by 10 sec) geometric mean of runtimes

	28.8	15.0	49.7	16.3	47.7	15.9	22.5	179	174
46 probs	1.92	1	3.31	1.08	3.18	1.06	1.50	11.9	11.6
solved	46	46	44	46	45	46	46	42	41
=====									
problem	CPXB	GRBB	MSKB	XPRB	CPXC	GRBC	XPRC	MATB	SASB
=====									

30 Oct 2018       =====

                  AMPL-NLP Benchmark

                  =====

                  (mittelmann@asu.edu)

IPOPT-3.12.11    projects.coin-or.org/Ipopt (MA97, also MA86 results, 4 threads)

KNITRO-11.1     www.artelys.com/knitro/

LOQO-7.03       www.princeton.edu/~rvdb/

PENNON-0.9       www.penopt.de/pennlp.html

SNOPT-7.7       www.scicomp.ucsd.edu/~peg/

CONOPT-3.17A    www.conopt.com/

WORHP-1.11(hyb) www.worhp.de/

XPRESS-8.5.1(Nonlinear) www.fico.com

FMINCON-2016a   www.mathworks.com

For AMPL models see [plato.asu.edu/ftp/ampl-nlp-source](http://plato.asu.edu/ftp/ampl-nlp-source)

The codes were run in default mode, except as indicated and with a CPU time limit of 2hrs on a 16GB, 3.4GHz Intel i7-2600. Means for table instances only.

Partial listing (123 instances; logfiles are complete)

```
=====
scaled shifted geom mean   6.1    1   34.9 29.1 48.3 56.0 7.82  1.60  24.5
src  problem               IPOPT KNIT  LOQO PENN SNOPT CONPT WORHP XPRESS FMNCON
=====
```

17 Oct 2018 =====  
 Large Second Order Cone Benchmark  
 =====  
 Hans D. Mittelmann (mittelmann@asu.edu)

Logfiles for these runs are at: [plato.la.asu.edu/ftp/socp\\_logs/](http://plato.la.asu.edu/ftp/socp_logs/)

MOSEK-8.1.0.58 MOSEK  
 CPLEX-12.8.0 CPLEX  
 GUROBI-8.1.0 GUROBI  
 XPRESS-8.5.1 XPRESS

These codes were tested on a selection of the SOCP problems from CBLIB2014.  
 The codes were run in default mode on an Intel i7-4790K (4.0 GHz, 32GB). Time limit 1 hr.

	3.17	1	1.14	1.34
-----				
problem	CPLEX	GUROBI	MOSEK	XPRESS
solved of 18	18	18	18	18
-----				

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17 Oct 2018 =====  
Mixed-integer SOCP Benchmark  
=====

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Logfiles for these runs are at: [plato.la.asu.edu/ftp/misocp\\_logs/](http://plato.la.asu.edu/ftp/misocp_logs/)

MOSEK-8.1.0.58 MOSEK  
CPLEX-12.8.0 CPLEX  
GUROBI-8.1.0 GUROBI  
XPRESS-8.5.1 XPRESS  
SCIP-6.0.0 SCIP

These codes were tested on a selection of the MISOCP problems from CBLIB2014 and from here.  
The codes were run in default mode (except mipgap=0) on an Intel i7-4790K (4.0 GHz, 32GB).  
Time limit 2 hrs.

Scaled shifted geometric means of runtimes (t/m counted as maxtime)

	4.82	1	12.4	1.67	37.6
problem	CPLEX	GUROBI	MOSEK	XPRESS	SCIP
solved of 47	37	46	32	45	31

21 Oct 2018 =====  
Mixed Integer Linear Programming Benchmark (MIPLIB2010)  
=====

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The following codes were run with a limit of 2 hours on the MIPLIB2010 benchmark set with the MIPLIB2010 scripts on two platforms.

1/4 threads: Intel i7-4790K, 4 cores, 32GB, 4GHz, available memory 24GB;

12 threads: Intel Xeon X5680, 12 cores, 32GB, 3.33Ghz, available memory 24GB

CPLEX-12.8.0: CPLEX

GUROBI-8.1.0 GUROBI

(F)SCIP/cpx/spx]-6.0.0: FiberSCIP (SCIP+CPLEX/SOPLEX on 1 thread)

CBC-2.9.8: CBC

GLKP-4.65: GLPK

LP\_SOLVE-5.5.2: LPSOLVE

XPRESS-8.5.1: XPRESS

MATLAB-2018b: MATLAB (intlinprog)

MIPCL-1.6.1: MIPCL

SAS-OR-14.3: SAS

Table for single thread, Result files per solver, Log files per solver

Table for 4 threads, Result files per solver, Log files per solver

Table for 12 threads, Result files per solver, Log files per solver

Statistics of the problems can be obtained from the MIPLIB2010 webpage.

The third line lists the number of problems (86 total) solved.

1 thr	CBC	CPLEX	GUROBI	SCIPC	SCIPS	XPRESS	MATLB	SAS	MIPCL	GLPK	LP_SOL
unscal	1639	72.2	41.6	239	330	83.1	3002	121	453	6925	5616
scaled	39	1.74	1	5.75	7.94	2.00	72.2	2.90	10.9	167	135
solved	53	87	87	83	76	86	32	84	76	2	7

4 thr	CBC	CPLEX	FSCIPC	FSCIPS	GUROBI	XPRESS	MIPCL	SAS
unscal	843	36.4	240	294	24.2	40.3	177	72.6
scaled	34.8	1.50	9.90	12.1	1	1.66	7.29	3.00
solved	66	86	80	79	87	87	84	85

12 thr	CBC	CPLEX	FSCIPC	FSCIPS	GUROBI	XPRESS	MIPCL	SAS
unscal	668	37.5	247	328	25.2	39.5	165	85.4
scaled	27	1.49	9.80	13.0	1	1.57	6.53	3.39
solved	69	87	78	76	87	87	82	82

1 Nov 2018 =====  
Mixed Integer Linear Programming Benchmark (MIPLIB2017)  
=====

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The following codes were run on the benchmark instances of the forthcoming MIPLIB2017 on an Intel Xeon X5680 (32GB, Linux, 64 bits, 2\*6 cores) and with 48 threads on an Intel Xeon E5-4657L, 48 cores, 512GB, 2.40GHz (available memory 256GB). 2/1 hours max. More codes to be added later.

CPLEX-12.8.0, GUROBI-8.1.0, XPRESS-8.5.1

no. of probs	CPLEX	GUROBI	XPRESS
12 threads	307	207	416
240	1.48	1	2.01
solved	195	212	180

no. of probs	CPLEX	GUROBI	XPRESS
48 threads	238	176	336
240	1.35	1	1.90
solved	199	211	180

30 Oct 2018

=====  
Binary QPLIB Benchmark  
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Logfiles at [plato.asu.edu/ftp/qplib\\_logs/](http://plato.asu.edu/ftp/qplib_logs/)

CPLEX-12.8.0	CPLEX
GUROBI-8.1.0	GUROBI
Baron-18.5.8	BARON
SCIP-6.0.0	SCIP-SOPLEX (only open source code included)
ANTIGONE-1.1	ANTIGONE
XPRESS-8.5.1	XPRESS
FSCIP-6.0.0	FiberSCIP+CPLEX

The above solvers were run on a 3 GHz Intel i7-5960X (8 cores, 48GB) on the binary nonconvex problems (128 total) from QPLIB.

Times given are elapsed times in seconds. Mipgap is zero, time limit 1hr; 8 threads, except SCIP.

Only those instances are shown for which at least one solver succeeded.

Shifted and scaled geometric mean of runtimes:

mean	2.89	1	18.5	40.2	44.5	1.82	30.8
solved	71	80	27	19	11	75	23
=====							
prob#	CPLEX	GUROBI	BARON	SCIP	ANTIGONE	XPRESS	FSCIP
-----							

27 Jul 2018

=====  
QPLIB-QCQP Benchmark  
=====

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Logfiles at [plato.asu.edu/ftp/qcqp\\_logs/](http://plato.asu.edu/ftp/qcqp_logs/)

Baron-18.5.8	BARON
ANTIGONE-1.1	ANTIGONE
SCIP-6.0.0	SCIP/CPLEX
COUENNE-0.5	COUENNE
CPLEX-12.8.0	CPLEX

The above solvers were run on a 3 GHz Intel i7-5960X (8 cores, 48GB) on the (nonconvex) QCQPs (37 total) with quadratic objective and the continuous QCQPs (52 total) with linear objective as well as the nonbinary QPs (19 total) from QPLIB. Times given are elapsed times in seconds. Mipgap is zero, time limit 3hrs. Only those instances are shown for which at least one solver succeeded. Shifted and scaled geometric mean of runtimes:

mean	2.36	1	2.28	4.54
solved	19	29	17	9
=====				
prob#	BARON	ANTIGONE	SCIP	COUENNE
-----				

11 Jun 2018

=====  
QPLIB-QCQP Benchmark  
=====

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(continued, nonbinary QPs)

prob#	BARON	ANTIGONE	SCIP	COUENNE	CPLEX
0018	t	6552	9	t	779
0031	3526	t	t	t	2666
0343	t	7682	8	t	771
2702	41	t	82	3762	71
2712	f	t	4530	t	t
3060	106	t	120	t	68
3122	2853	t	1804	t	206
3523	1119	t	2391	t	189
3554	t	t	t	t	14
3790	336	t	t	t	2
3870	t	t	t	t	2896
8505	t	135	t	1410	18
8777	t	t	t	t	6679
9030	t	t	t	t	1
9048	922	t	t	t	t

30 Oct 2018

```

=====
Convex Discrete QPLIB Benchmark
=====
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```

Logiles at [plato.asu.edu/ftp/convex\\_logs/](http://plato.asu.edu/ftp/convex_logs/)

```

CPLEX-12.8.0    CPLEX
GUROBI-8.1.0    GUROBI
MOSEK-8.1.0.53 MOSEK
XPRESS-8.5.1    XPRESS
KNITRO-11.1     KNITRO
Baron-18.5.8    BARON
SCIP-6.0.0      SCIP with SOPLEX-4.0.0
Bonminh-1.8     BONMIN

```

The above solvers were run on a 3 GHz Intel i7-5960X (8 cores, 48GB) on the 31 discrete convex problems from QPLIB. Times given are elapsed times in seconds. Mipgap zero, time limit 2hrs, 8 threads; SCIP 1 thread  
 Shifted and scaled geometric mean of runtimes:

```

mean      2.90      1      8.18      3.07      11.6      9.24      12.8      10.8      13.4
solved    20      22      11      14      9      14      12      9      11

```

```

=====
prob#  CPLEX  GUROBI  MOSEK  XPRESS  KNITRO  BARON  SCIPC  BONMIN  SCIPS
-----

```



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=====  
Commercial Solver Strengths  
=====

ANTIGONE	nonconvex MIQCP
BARON	nonconvex MINLP
CPLEX	MILP, nonconvex MIQP
Gurobi	LP/Simplex, LP/Barrier, SOCP, MILP, convex MIQCP
KNITRO	NLP
XPRESS	LP/Simplex, LP/Barrier, MISOCP, binary QP,
MOSEK	SDP, SOCP

=====  
Noncommercial Solver Strengths  
=====

BONMIN	convex MIQCP
BPMPD	QP
CSDP, SDPT3	SDP
CLP	LP/Simplex
IPOPT	NLP
SCIP	convex MIQCP, nonconvex MINLP

coming soon:

more MIPLIB2017, QPLIB, MINLP etc

slides at: <http://plato.asu.edu/talks/>

*Thank you!*